APPENDIX I

ESTIMATION OF INCOMING LONGWAVE RADIATION

B. R. Gardner and B. L. Blad

Blad (1976) described a method by which incoming longwave radiation (B*) can be directly measured. The method consists of measuring the apparent temperature of an aluminum plate with an infrared thermometer (IRT) and its actual temperature with embedded thermocouples. The emissivity of the plate must be known. B* is calculated from the following expressions.

$$B^* = \frac{\sigma T_{IR}^4 - \varepsilon_p T_p^4}{1 - \varepsilon_p}$$

where σ is the Stephan-Boltzmann constant, ε_p is the emissivity of the aluminum plate, T_p is the observed infrared temperature (°K) and T_{IR} is the thermocouple temperature of the aluminum plate (°R).

Idso and Jackson (1969) studied the relationship between clear-sky B* and screen-level air temperature. They concluded that B* could be accurately estimated under clear-sky conditions using the following equation:

$$B^* = \sigma T^4 (1 - 0.261 \exp [-7.77 (10^{-4}) (273 - T)^2])$$

where T is screen-level air temperature (°K).

The method described by Blad has the advantage of theoretical accuracy and is relatively simple to use. By comparison the method developed by Idso and Jackson is more simple to use. The two methods were compared at mid-day on 26 clear days throughout the 1978 growing season at the Sandhills Agricultural Laboratory (Fig. 1).

The results of the comparison indicate that the B* values obtained with measurements were generally higher than those calculated with the Idso-Jackson equation. This does not mean that the Idso-Jackson equation is invalid, however.

True canopy temperature is calculated from the following expression:

$$T_c = \frac{(\sigma T_{IR}^{\ 4} - (1 - \varepsilon_c)\ B^*)^{\frac{1}{4}}}{\varepsilon_c \sigma}$$

where ε_c is the emissivity of the crop and T_c is true canopy temperature (°K). Since ε_c for most vegetative surfaces is about 0.97, it is apparent that the effect of even fairly large B* values on corrected temperatures will be relatively small. Consequently, we computed the midday IRT temperature of well-watered corn for 63 days during the season. These days represent wide ranges of cloudy, partly-cloudy and clear skies (Fig. 2). Regression analysis indicates that canopy temperature estimates using B* values from either method differed by no more than 0.3 C for crop temperatures between 20 and 35 C.

We conclude that either method of estimating B* will yield sufficiently accurate B* values for calculating mid-day crop temperatures for operational purposes. For research purposes, however, we feel the theoretical accuracy of the measurement method is preferable.

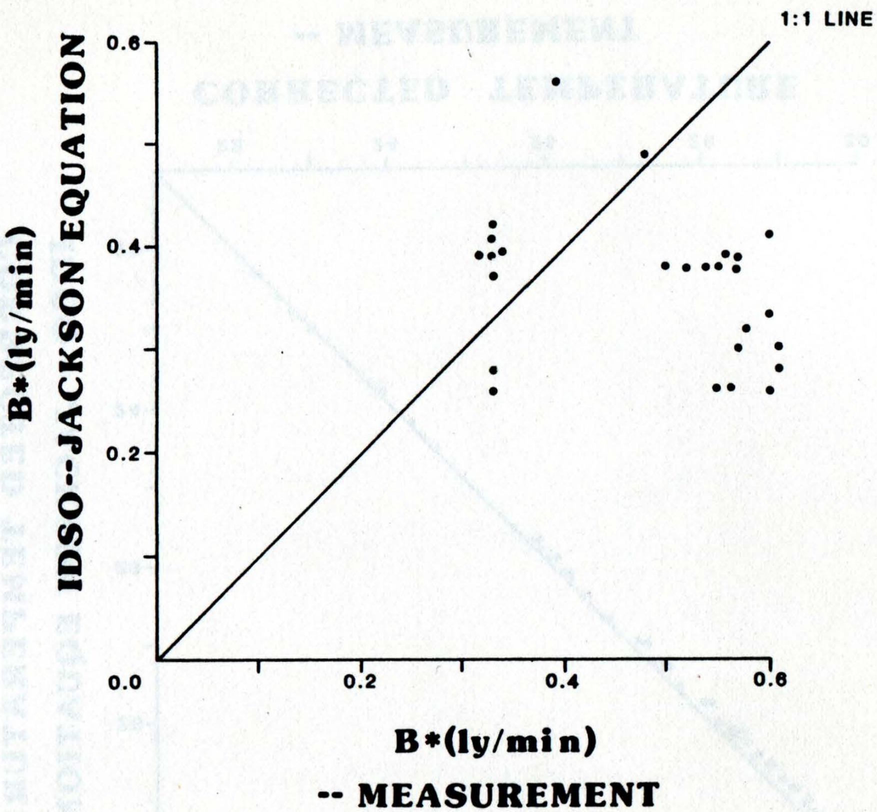

Fig. 1. Comparison between the Idso-Jackson (1969) equation for estimating incoming longwave radiation (B*) and a method for directly measuring B* (Blad, 1976).

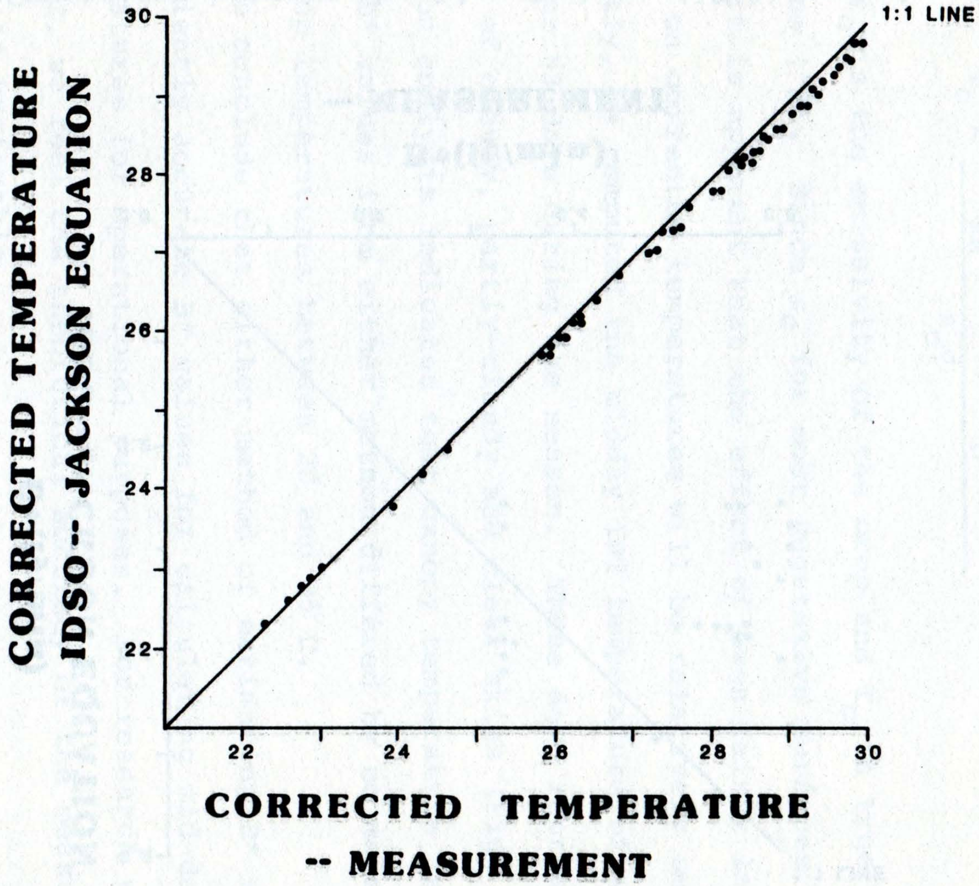

Fig. 2. Corrected mid-day infrared canopy temperature of well-irrigated corn, calculated using the Idso-Jackson equation (1969) and the direct measurement method (Blad, 1976).

REFERENCES

Blad, B. L. and N. J. Rosenberg. 1976. Measurement of crop temperature by leaf thermocouple, infrared thermometry and remotely sensed thermal imagery. Agron. J. 68:635-641.

Idso, S. B. and R. D. Jackson. 1969. Thermal radiation from the atmosphere. J. Geophys. Res. 74:5397-5403.